REVERSE LINK, CLOSED LOOP POWER CONTROL IN A CODE DIVISION MULTIPLE ACCESS SYSTEM

This is a continuation of application Ser. No. 08/272,484, filed Jul. 11, 1994 now U.S. Pat. No. 5,603,096.

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates generally to radiotelephone communications. More particularly, the present invention relates to reverse link power control in a radiotelephone system.

II. Description of the Related Art

The Federal Communications Commission (FCC) governs the use of the radio frequency (RF) spectrum, deciding which industry gets certain frequencies. Since the RF spectrum is limited, only a small portion of the spectrum can be assigned to each industry. The assigned spectrum, therefore, must be used efficiently in order to allow as many frequency users as possible to have access to the spectrum.

Multiple access modulation techniques are some of the most efficient techniques for utilizing the RF spectrum. Examples of such modulation techniques include time division multiple access (TDMA), frequency division multiple access (FDMA), and code division multiple access (CDMA).

CDMA modulation employs a spread spectrum technique for the transmission of information. A spread spectrum system uses a modulation technique that spreads the transmitted signal over a wide frequency band. This frequency band is typically substantially wider than the minimum bandwidth required to transmit the signal. The spread spectrum technique is accomplished by modulating each baseband data signal to be transmitted with a unique wide band spreading code. Using this technique, a signal having a bandwidth of only a few kilohertz can be spread over a bandwidth of more than a megahertz. Typical examples of spread spectrum techniques can be found in *Spread Spectrum Communications*, Volume i, M. K. Simon, Chap. 5, pp. 262–358.

A form of frequency diversity is obtained by spreading the transmitted signal over a wide frequency range. Since only 200–300 kHz of a signal is typically affected by a frequency selective fade, the remaining spectrum of the transmitted signal is unaffected. A receiver that receives the spread spectrum signal, therefore, will be affected less by the fade condition.

In a CDMA-type radiotelephone system, multiple signals are transmitted simultaneously at the same frequency. Such a CDMA system is disclosed in U.S. Pat. No. 4,901,307 to Gilhousen et al. and assigned to Qualcomm, Inc. In this type system, a particular receiver determines which signal is intended for that receiver by the unique spreading code in the signal. The signals at that frequency without the particular spreading code intended for that particular receiver appear to be noise to that receiver and are ignored.

FIG. **1** shows a typical prior art CDMA transmitter for use on the reverse channel of a radiotelephone system, the reverse channel being the link from the mobile to the base station. A digital baseband signal is first generated by a vocoder (voice encoder/decoder). The vocoder (**100**) digitizes an analog voice or data signal using an encoding process such as the Code Excited Linear Prediction (CELP) process that is well known in the art.

The digital baseband signal is input to a convolutional encoder (**101**) at a particular rate, such as 9600 bps. The encoder (**101**) convolutionally encodes the input data bits into data symbols at a fixed encoding rate. For example, the encoder (**101**) could encode the data bits at a fixed encoding rate of one data bit to three data symbols such that the encoder (**101**) outputs data symbols at a 28.8 ksym/s rate with a 9600 bps input rate.

The data symbols from the encoder are input to an interleaver (**102**). The interleaver (**102**) scrambles the symbols such that any symbols lost over the channel won't be contiguous symbols. Therefore, if more than one symbol is lost in the communications channel, the error correcting code is able to recover the information. The data symbols are input into the interleaver (**102**) in a column by column matrix and output from the matrix row by row. The interleaving takes place at the same 28.8 ksym/s data symbol rate that the data symbols were input.

The interleaved data symbols are input to a modulator (**104**). The modulator (**104**) derives a sequence of fixed length Walsh symbols from the interleaved data symbols. In 64-ary orthogonal code signaling, the interleaved data symbols are grouped into sets of six to select one out of the 64 orthogonal codes to represent the set of six data symbols. These 64 orthogonal codes correspond to Walsh symbols from a 64 by 64 Hadamard matrix wherein a Walsh symbol is a single row or column of the matrix. The modulator outputs a sequence of Walsh symbols, corresponding to the input data symbols at a fixed symbol rate, to one input of an XOR combiner (**107**). The set of six grouped Walsh symbols has a length of 1.25 milliseconds (ms) and is typically referred to as a power control group.

A pseudo random noise (PN) generator (**103**) uses a long PN sequence to generate a user specific sequence of symbols. In a mobile radiotelephone having an electronic serial number (ESN), the ESN can be exclusive-ORed with the long PN sequence to generate the sequence, making the sequence specific to that radiotelephone user. The long PN generator (**103**) inputs and outputs data at the spreading rate of the system. The output of the PN generator (**103**) is coupled to the XOR combiner (**107**).

The Walsh code spread symbols from the combiner (**107**) are next spread in quadrature. The symbols are input to two XOR combiners (**108** and **109**) that generate a pair of short PN sequences. The first combiner (**108**) XORs the Walsh code spread symbols with the in-phase (I) sequence (**105**) while the second combiner (**109**) XORs the Walsh code spread symbols with the quadrature phase (Q) sequence (**106**).

The resulting I and Q channel code spread sequences are used to bi-phase modulate a quadrature pair of sinusoids by driving the power level of the pair of sinusoids. The sinusoidal output signals are then summed, bandpass filtered, translated to an RF frequency, amplified, filtered, and radiated by an antenna.

The typical prior art CDMA transmitter used on the forward channel of a radiotelephone system, the link from the base station to the mobile, is similar to the reverse channel. This transmitter is illustrated in FIG. **2**. The difference between the forward and reverse channel transmitters is the addition of a Walsh code generator (**201**) and power control bit multiplexer (**220**) between the PN generator combiner (**103**) and the quadrature spreading combiners (**108** and **109**) for the forward channel transmitter.

The power control bit multiplexer (**220**) multiplexes a power control bit in place of another bit in the frame. The